U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Research and Development Opportunities in Energy Management Control Systems

BTO Peer Review

Emerging Technologies Strategy Overviews

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Introduction to special section

Today's Session

Hear our latest thinking now (and later)

Ask questions

Share your feedback

Listen for more from BTO, on strategies

The mission

The Building Technologies Office (BTO) conducts research, development, and demonstration activities to accelerate the adoption of technologies and techniques that enable high-performing, affordable buildings that meet Americans' need for resiliency and health while also supporting a reliable energy system.

90%

The amount of time people spend in buildings.

74%

Amount of electricity consumed by buildings.

$374 billion

Amount spent on energy costs annually.

BTO RD&D Activities Support America

- Energy Efficiency
- Energy Affordability
- Innovation
- Industrial Competitiveness
- Infrastructure
- Energy Reliability and National Security
- Resilience
- Indoor Environment and Health

A practical, inclusive definition of innovation

The [Heilmeier Questions]():

01 Problem

Stated without jargon

02 Impact

If you succeed, what changes and who cares?

03 Status

How is it done today?

04 Proposal

What is the new approach, why will it succeed, and what will the output be?

05 Midterm checks

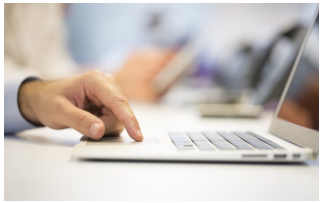
How will we know we're on the right track?

06 How much does it cost?

How long will it take? What are the risks?

Innovation for building technology is broad

It includes R&D for product development, testing, and validation. But also!



Market transformation

Partnership models

Service delivery modes

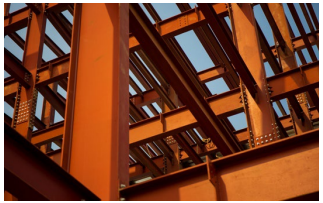
Value chain

Contractors

Trades

Specifiers

Reps



Supply chain

Materials

Components

System integration

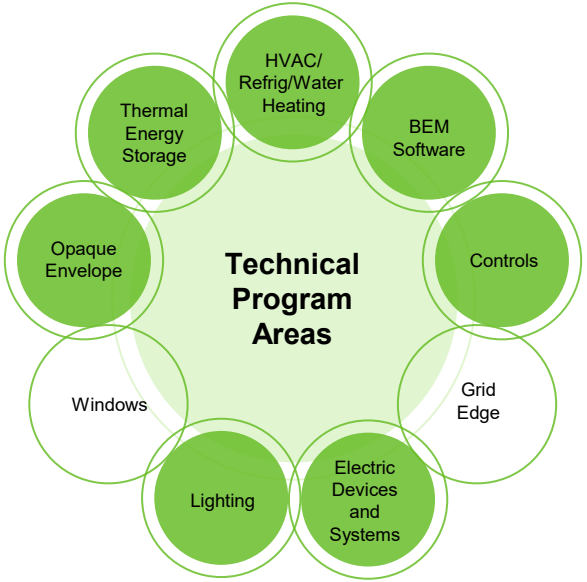
Logistics

Serendipity

Partnerships

Alignment

What does this strategy mean for DOE's applied R&D for buildings?



Reduce first costs

Make it easy

Deliver performance that matters

Ask, who's missing that we need?

Building Controls Energy Shot – Big Goals

1. **Reduce hardware and software installation cost payback for upgrading existing building control systems to three years.**
   - Based on energy and operational cost savings attributable to the system upgrade.
2. **Reduce the lifetime labor requirements of programming and (retro-)commissioning building control systems by 3x**
   - Compared to the traditional manual programming and commissioning process over the life of the control system.
3. **Increase energy/demand reduction, thermal comfort and indoor environmental quality by 20%**
   - Compared to pre-retrofit (or baseline) energy use and the percentage of time the building is outside applicable thermal comfort and IEQ industry standards on a continuous basis.

Building Controls: distinct efforts for small/medium buildings and new/retrofits for large buildings

Problem

High cost and complexity for control system installation and upgrades Existing controls are often replaced during modernization, requiring expensive hardware and software upgrades, application reprogramming and frequent retro-commissioning using skilled labor.

System data integration and programming is labor intensive requiring a highly skilled workforce

- Lack of standard semantic data models and control methods results in vendor specific data tagging and control applications.

Rapid system performance degradation requires frequent retro-commissioning

- Self-configuration and auto-commissioning is rare, vendor-specific and doesn't verify and maintain on-going system performance.

Solutions and Benefits

Implement continuous system commissioning and optimization as an overlay to existing control systems

- Develop a data normalization gateway in the building to allow cloud-based optimization software to use existing system sensing and control data in a standard format, allowing multi-vendor system modernization without hardware/software "rip and replace" avoiding vendor lock-in.
- Incrementally expand system capabilities through plug-and-play IoT devices, web-services and user apps.

Implement automated data translation tools; self-adaptive control algorithms; automated commissioning and continuous performance management capabilities

- Use system configuration data analysis (point lists, programs) and automated system test sequences to translate system data tags and functions.
- Implement adaptive supervisory control and continuous commissioning capabilities which are vendor neutral.
- Develop continuous building performance management capabilities to verify installed performance and enable "control retrofit as a service" business models and incentives.

EMCS Technology Solutions

- **Manage system complexity:** While some internal system complexity is needed to support systems integration and advanced monitoring control functionality, EMCS need to be simple to install, maintain, expand, and operate for non-expert users.
- **Invest in workforce development:** The EMCS industry faces significant challenges including a lack of skilled workers, high turnover rates, limited training opportunities, and difficulty keeping up with the rapidly changing technology.
- **Advance continuous building performance measurement:** While typically performed manually using monthly utility bill data, building performance measurement should be continuous and include occupant comfort and indoor air quality parameters.
- **Develop and implement building controls technology standards:** The lack of standardization has led to system interoperability issues, poor data quality, vendor lock-in, higher costs for upgrades, and a lack of necessary tools for incorporation into workflows.
- **Define building performance metrics and baselines:** There is a need to develop standard KPIs, metrics, and targets for EMCS technologies and installations that can be used to quantify the impact of improved functionality and operations.
- **Enhance and integrate building control simulators and emulators:** Simulators and emulators allow for testing and evaluating the performance of an EMCS in a controlled environment before actual field implementation.
- **Load flexibility prediction and evaluation:** Building owners, operators, and the power distribution grid benefit from the ability to predict how a building can adjust its energy consumption in response to grid demands.
- **Demonstrate value through field validations:** Field validations are essential to demonstrate the value proposition of EMCS technology and establish its credibility in the building sector.
- **Leverage human-machine interface research:** By focusing on the interface between humans and machines, human-machine interface research can help to assure that building management systems are effective, efficient, and user-friendly.

RFI on Energy Management and Control Systems RDO

Issued in June 2022

- DOE received 44 responses (161 pages)

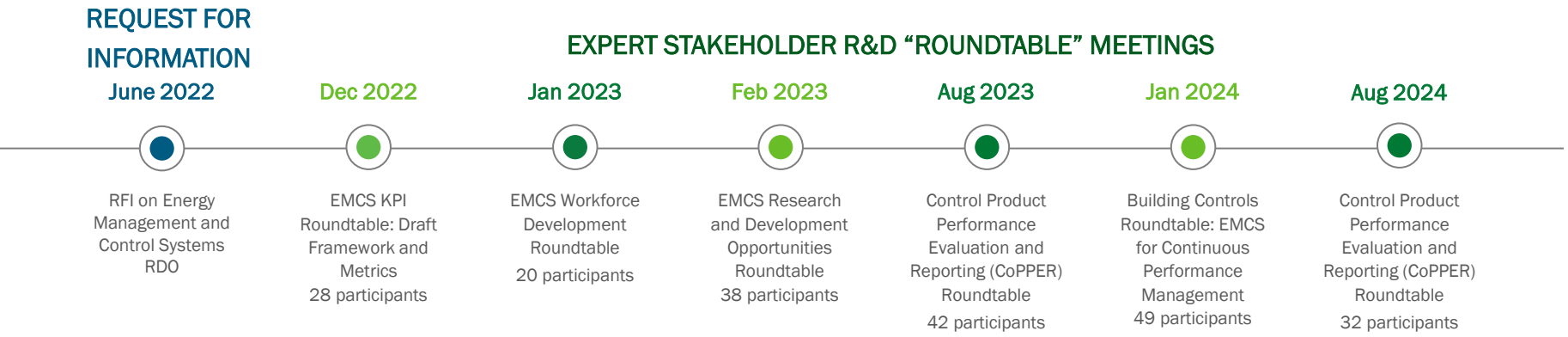
RFI topics: Hardware, Software, Cybersecurity, and Interoperability

- Technical Barriers, Adoption Barriers, Research Areas

Key Stakeholder Input

- Installation and commissioning cost
- Shortage of a skilled workforce
- Integration and interoperability
- Lack of value proposition

What is the stakeholder engagement? How are we getting inputs from others in DC? Others outside DOE?



EMCS Technology Objectives – Short / Medium Term

1 Plug-and-play

EMCS technologies that are designed to be easily installed and integrated into existing building systems without requiring major retrofitting or disruption to building operations.

2 Self-configuring

Self-configuring is the ability of a system to automatically configure itself based on the available resources and the demands of the system, eliminating the need for complex programming and configuration during installation.

3 Self-healing

Self-healing is the ability of a system to automatically detect and recover from errors or failures and compensate for a range of problems without human intervention.

4 Self-learning

Self-learning is the ability of a system to improve its performance over time based on experience and data analysis.

5 Intuitive operation and oversight

An EMCS should be both easy to use and conducive to human oversight, combining an intuitive design with sophisticated autonomous functions.

6 Human-in-the-loop

An EMCS should actively involve operators in the decision-making process, particularly for advanced building control and optimization strategies where the system provides data-based operational recommendations.

7 Operator preference learning

Along with learning from historical and real-time system data, an EMCS should automatically incorporate building operator and occupant preferences over time.

8 Explainable solutions

The ability of a system to provide a clear and understandable description for how it arrived at a particular control or diagnostic recommendation or solution.

9 Integrated building system management

A comprehensive approach to building energy management involves end-to-end automation of all building systems from hardware and networking to data management, analytics, and application software.

10 Building-to-grid integration

The ability of the EMCS to not only manage the timing of energy consumption within the building, but also to communicate and coordinate with the external power grid and service providers.

EMCS KPIs and Metrics

KPI		Metrics
Energy and Grid Performance	HVAC Energy Use Reduction	% HVAC energy use reduction attributable to EMCS functionality
	Lighting and Plug Load Energy Reduction	% greenhouse gas emissions reduction attributable to EMCS functionality
	Electrical Demand Reduction	% peak short-term electrical demand reduction attributable to EMCS functionality (1-2 hours)
	Electrical Load Shifting	% peak long-term electrical demand shifting attributable to EMCS functionality (2-4 hours)
Operational Performance	Occupant Health	% occupied time within acceptable IAQ conditions (e.g., ASHRAE Std 62.1)
	Occupant Thermal Comfort	% occupied time within acceptable thermal comfort conditions (e.g., ASHRAE Std 55)
	Operational Complexity	# training hours required to achieve basic EMCS operator proficiency

Note: Separate baselines and 2035/2050 targets will be established for small commercial and large commercial buildings as well as EMCS installations in disadvantaged communities

EMCS KPIs and Metrics

KPI		Metrics
System Economics	System Payback Period	# years to achieve simple payback based on system installation and operating cost
	System Installation Costs	System hardware and software costs per square foot
	System Installation Labor	System engineering, installation, configuration, and programming hours per square foot
	Energy Analytics Installation Costs	Energy analytics/optimization engineering, installation, and programming hours per monitored point
	Installation Complexity	# training hours required to achieve basic EMCS technician proficiency
System Applications	Advanced EMCS	% installations with advanced EMCS functionality (e.g., supervisory control, metering, monitoring)
	Demand Flexibility	% installations with active demand management (e.g., grid integration, demand response, load shifting)
	Energy Analytics and Optimization	% installations with advanced building data analytics and system optimization (e.g., EIS, FDD)
System Integration	Building Systems Integration	% installations with multi-system data integration (e.g., HVAC, lighting, plug loads, security, life safety)
	DER Integration	% installations with grid and distributed energy resource integration (e.g., solar PV, storage, EV charging)
	Building-Grid Integration	% installations with electric grid and/or energy service provider data integration

Note: Separate baselines and 2035/2050 targets will be established for small commercial and large commercial buildings as well as EMCS installations in disadvantaged communities

Next Steps

- Map customer journeys and collect market and cost data
- Develop plan for establishing EMCS KPIs/metrics
- Publish EMCS article in an industry trade publication - ASHRAE Journal
- Coordinate CoPPER FY25 project plans with NIST and the national labs
- Develop FY25 stakeholder engagement plan – initial session with CBI at ASHRAE
- Develop building controls/grid-edge portfolio strategy

Thank you!

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